DOCUMENT RESUME

ED 256 498 PS 015 112

AUTHOR Dowler, Jeffrey K.; Jacobson, Sandra W.
TITLE Behavioral Effects of Pre- and Postnatal Exposure to Smoking, Alcohol, and Caffeine in 5-Month-Old Infants.
SPONS AGENCY Environmental Protection Agency, Washington, D. C.
PUB DATE Apr 85
NOTE 15p.; Paper presented at the Biennial Meeting of the Society for Research in Child Development (Toronto, Ontario, Canada, April 25-28, 1985).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Alcoholic Beverages; Cognitive Development; *Drinking; Exploratory Behavior; *Infants; *Mothers; Motor Development; Personality; Pregnancy; *Prenatal Influences; Sleep; *Smoking; Whites
IDENTIFIERS Breastfeeding; *Caffeine; *Postnatal Influences

ABSTRACT

This study examined the behavioral effects of prenatal and postnatal exposure to smoking, alcohol, and caffeinated beverages on 5-month-old infants. The sample consisted of 179 Caucasian infants and their mothers. All mothers were 19 years of age or older and had at least a tenth-grade education. Mental and motor portions of the Bayley Scales of Infant Development were administered to all infants. In addition, irritability or fussiness of the infant during testing was rated. Information regarding the mother's smoking and consumption of alcohol and beverages containing caffeine prior to and during pregnancy was obtained in an interview on the second day following delivery. Postnatal consumption data were obtained in a questionnaire mailed about 1 year after the 5-month assessment. Exposure measures for smoking, alcohol, and caffeine were calculated for the periods before, during, and following pregnancy, yielding nine independent variables. Outcome measures included the 5-month Bayley scores; the irritability rating; the infant's sensory, perceptual, and motoric exploration of the environment; and the mother's reports of infant sleep difficulties. Findings were consistent with the hypothesis that behavioral effects may be directly or indirectly attributable to smoking and use of caffeinated and alcoholic beverages at levels generally assumed to be harmless. (RH)

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ED256498

Behavioral Effects of Pre- and Postnatal Exposure to Smoking, Alcohol, and Caffeine in 5-month-old Infants

Jeffrey K. Dowler

New England Medical Center

and

Sandra W. Jacobson

Wayne State University

This research was funded under Grant #CR808520010 to Greta G. Fein from the United States Environmental Protection Agency. Presented at the meeting of the Society for Research in Child Development, April 25-28, 1985, Toronto. Joseph L. Jacobson and Gail A. Brumitt collaborated in this research. We wish to thank Carol Alexander, Pat Yaros, and Gwen Hendrikse for their assistance in data collection, and Joel Ager for statistical analysis. First author's address: Division of Child Psychiatry, Box 395, New England Medical Center, 171 Harrison Avenue, Boston, MA 02111.

PS 015112

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Introduction

High levels of alcohol consumed during pregnancy have been associated with the cluster of physical and behavioral effects known as the Fetal Alcohol Syndrome (e.g., Abel, 1980; Jones & Smith, 1975; Streissguth, 1976), and smoking, with decreased birth weight (e.g., U.S. Public Health Service, 1979). Exposure to more moderate levels of alcohol (i.e., less than 1 ounce of absolute alcohol per day) has also been associated with behavioral effects in newborns. Jacobson, Fein, Jacobson, Schwartz, and Dowler (1984) reported greater placidity in 3-day-old infants exposed to moderate levels of alcohol. Landesman-Dwyer, Keller, and Streissguth (1978) reported that infants spent more time with their eyes open and engaging in hand-to-face movements, and less time at high levels of body activity (e.g., vigorous movement of two or more limbs) when exposed to higher levels of alcohol in utero. Few studies have examined the behavioral outcomes of prenatal exposure to caffeine and smoking, however, and no study has explored the effects of these substances when ingested through breastfeeding directly. Finally, it is not known whether behavioral effects of these substances observed in the newborn persist beyond the neonatal period. The present study, therefore, examined behavioral effects associated with pre- and postnatal exposure to smoking, alcohol, and caffeinated beverages in 5-month-old infants.

Method

Subjects

The sample consists of 179 (97 male and 82 female) Caucasian

5-month-old infants and their mothers. This sample was obtained in connection with a longitudinal study of the effects of prenatal exposure to an environmental pollutant, polychlorinated biphenyls (PCB's), on infant development (Jacobson, Jacobson, Schwartz, & Fein, 1984). The infants included in the present study were those seen at 5 months whose mothers also completed a mail-in questionnaire about 1 year later.

The characteristics of the sample are shown in Table 1. Two are the larger members of twins, neither of whom died in infancy, and 39% are first born. All of the infants were healthy at birth with the exception of one infant with respiratory distress whose breathing became normal within 3 hours of birth. All had 5-minute Apgar scores of 7 or better, and none were small-for-gestional-age according to the criteria of Lubchenco, Hansman, Dressler, and Boyd (1963). All infants were healthy when seen for the 5-month assessment.

All mothers were 19 years of age or older and had at least a 10th grade education. Most were married (97%); two of the five unmarried mothers were supported by welfare. The sample was predominantly middle class, with only 1% of the families' primary wage earners classified as menial or unskilled (Hollingshead & Redlich, 1958). The majority of the mothers (92%) began receiving prenatal care during the first trimester, and all had begun by the sixth month.

Procedure

The mothers were initially recruited into the study on the morning following delivery. The characteristics of this sample have been described previously (see Jacobson, Jacobson, Schwartz,

& Fein, 1984). All 313 mothers who took part in the neonatal evaluation were asked to participate in a follow-up assessment of their infants at 5 months of age except for two whose infants were in intensive care for a prolonged period and one whose infant had died. Fifty-six (18%) of these were unavailable at 5 months, could not be contacted, or did not keep the appointment; an additional 21 (7%) declined to participate further in the study.

The mental and motor portions of the Bayley Scales of Infant Development (Bayley, 1969) were administered to all infants. In addition, irritability or fussiness of the infant during testing was rated on a 7-point scale by an independent observer using videotapes of the Bayley assessment.

Exposure Measures

Information regarding the mother's smoking and consumption of alcohol and beverages containing caffeine prior to and during pregnancy was obtained in an interview on the second day following delivery. Postnatal consumption data was obtained in a questionnaire mailed to the 280 mothers who had not formally dropped out of the study. The questionnaire was sent to the mothers about 1 year after the 5-month assessment; 206 (75%) of the mothers returned the questionnaire. The average age of the infants when the questionnaire was completed was 19.14 months (SD=4.1).

Caffeine consumption was based on a weighted sum of reported daily servings of coffee, tea, and cola beverages; decaffeinated coffee and herbal and medicinal teas were not included. Because tea and cola beverages contain roughly one third of the average caffeine content of coffee (Gilbert, Marshman, Schwieder, & Berg, 1976), total daily caffeine consumption was estimated by assigning

coffee three times the weight of the other beverages. Each serving of coffee or tea was assumed to be approximately 225 ml; each serving of a caffeinated soft drink, 355 ml (Gilbert et al., 1976; Jacobson et al., 1984).

Mean daily intake of absolute alcohol (AA) was estimated from the reported rate of consumption of beer, wine, and hard liquor. Mean daily AA was calculated in the manner described by Kuzma and Kissinger (1981). All servings of a given beverage were assumed to be the same size and to contain a constant proportion of alcohol by volume.

Smoking was estimated by the number of packs of cigarettes smoked on a daily basis.

The exposure measures for smoking, alcohol, and caffeine were calculated for before, during, and following pregnancy, yielding nine independent variables.

Statistical Analysis

The relationships between 28 control variables and each of the nine exposure measures were examined. Where a control variable was significantly correlated with an exposure measure ($p < .10$) it was considered a potential confound. Pearson correlations between the potential confounds and exposure are shown in Table 2.

The outcome measures in the present study include 5-month Bayley scores and a 7-point rating of irritability during the Bayley. In addition to the summary scores provided by the Bayley (i.e., the MDI and the PDI), a principal components analysis was calculated using items from the mental and motor scales in the manner recommended by McCall, Eichorn, and Hogarty (1977). The first principal component obtained in this analysis reflects

the 5-month-old infant's sensory, perceptual, and motoric exploration of the environment. Additionally, mothers reported whether their infants had exhibited sleep disturbances during the period prior to the 5-month assessment. Presence of sleep difficulties (reported as present/absent) was also included as an outcome measure.

Pearson correlations were performed initially to examine the relationships between the outcome measures and consumption. When the zero-order correlation of outcome with exposure attained or approached conventional significance levels ($p < .10$), that relation was examined further in a multiple regression analysis in which the effects of the appropriate potential confounds were statistically partialled out. An exposure effect was considered significant when its unique contribution to R^2 was significant at $P < .05$.

Exposure from nursing is a function of both contaminated levels in breast milk and amount of milk ingested by the infant. Postnatal exposure was, therefore, assessed in a regression analysis based on postnatal maternal consumption report, number of weeks of nursing, and an interaction term weighing postnatal maternal consumption by weeks of nursing. These three variables were entered in a regression after first removing the variance associated with their potential confounds.

Exposure and control variables which deviated from normality (skew < 2.0) were log transformed prior to all analyses.

Results and Discussion

Mean consumption levels for all three substances for consumers only are shown in Table 3. The results of the multiple regression analyses are summarized in Table 4. Bayley MDI and PDI scores were

not significantly related to prenatal exposure to caffeine or alcohol, nor were any of the clusters associated with exposure to these substances in utero. Caffeine exposure via breastfeeding was associated with higher Bayley psychomotor scores and better performance on the first principal component. These results suggest that caffeine exposure from nursing may stimulate sensorimotor performance at this age. In contrast, infants whose mothers consumed more alcohol postnatally received lower scores on the first principal component. While this effect may have been due, in part, to the type of stimulation provided by the mothers consuming more alcohol, the effect of alcohol exposure via breastfeeding was also significant.

Alcohol consumption before pregnancy was related to greater irritability during the Bayley exam, as was postnatal consumption. However, the effect of alcohol exposure via breastfeeding on irritability was not significant. Thus, infants whose mothers consumed alcohol postnatally were rated as being more irritable by an independent rater regardless of whether they were breastfed. Infants whose mothers smoked more heavily before pregnancy reportedly had fewer sleep difficulties than those whose mothers smoked less or not at all. Exposure to smoking through breastfeeding was also associated with fewer sleep disturbances during the postnatal period.

The findings presented here are consistent with the hypothesis that behavioral effects may be directly or indirectly attributable to smoking and use of caffeinated and alcoholic beverages at levels which are generally assumed to be harmless. Both caffeine and smoking apparently can exert effects directly on the infant via nursing, while the effects due to alcohol consumption appear to have resulted from both direct exposure through breastfeeding

and indirect exposure via the mother-infant interaction.

Table 1

Characteristics of the Sample (N = 179)

	Mean	SD	Range
Neonatal characteristics			
Birth weight (g)	3592.1	501.4	2159.1 - 5028.4
Head circumference (cm)	35.2	1.3	31.1 - 41.3
Crown-heel length (cm)	51.4	2.0	41.4 - 56.0
Gestational age			
Obstetrician's estimated date of confinement	39.3	1.7	34.9 - 44.4
Ballard[a]	39.5	1.2	36.0 - 42.0
5-minute Apgar score	8.9	0.5	7.0 - 10.0
Parity	2.0	1.0	1.0 - 5.0
5-month characteristics			
Weight (g)	7397.3	931.6	5340.9 - 10000.0
Head circumference (cm)	42.6	1.3	36.3 - 46.5
Crown-heel length (cm)	64.9	2.6	59.1 - 71.3
Family characteristics			
Maternal age	27.2	4.1	19.0 - 39.0
Maternal education (years)	13.8	1.9	10.0 - 19.0
Socioeconomic status[b]	42.0	13.1	17.0 - 66.0

[a]Ballard, Novak, and Driver (1979).

[b]Hollingshead index (Hollingshead & Redlich, 1958).

Table 2

Pearson Correlations Between Potential Confounds and Consumption (N = 179)

	Smoking			Alcohol			Caffeine		
	Prior	During	Post	Prior	During	Post	Prior	During	Post
Socioeconomic status[a]	-.16*	-.24**	-.21**	-	-	-	-.22**	-.25**	-.16*
Maternal age	-.17*	-.14+	-.18**	-	.14+	-	-	-	-
Maternal education	-.23**	-.33***	-.34***	.18*	.17*	.13+	-	-	-.13+
Parity[b]	-	-	-	-	-	-	-	.23**	.14+
Sex of infant	-	-	-	-	.12+	-	-	-	-

[a]Hollingshead index (Hollingshead & Redlich, 1958). [b]Coded as first born/later born.

+$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

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Table 3

Mean Consumption Levels for Consumers

Before, During, and Following Pregnancy (N = 179)

Substance	N	Mean	SD
Smoking			
Prior[a]	61	1.01	0.54
During[b]	43	0.79	0.57
Post[a]	54	0.90	0.56
Alcohol			
Prior[a]	96	0.33	0.42
During[a]	59	0.17	0.24
Post	151	0.22	0.28
Caffeine			
Prior[b]	165	2.24	2.47
During[b]	149	1.29	1.69
Post	177	2.15	2.62

[a]Data are missing for one woman. [b]Data are missing for two women.

Table 4

Multiple Regression Analyses for Observed Effects of Smoking, Alcohol, and Caffeine (N = 179)

Substance	Observed effect	Standardized regression coefficient	F ratio[a]
Smoking			
Prior	Sleeping[b]	-.15	3.96*
Post	Sleeping[b]		
	consumption level	.03	
	breastfeeding	.26	4.47*
	interaction	-.19	
Alcohol			
Prior	Irritability	.19	4.70**
Post	Irritability	.32	4.83**
	Principal component	-.35	7.91**
	Principal component		
	consumption level	-.35	
	breastfeeding	-.14	2.70*
	interaction	.31	

Table 4 (continued)

Caffeine			
Post	PDI		
	consumption		
	level	.08	
	breastfeeding	.10	2.98*
	interaction	-.13	
	Principal component		
	consumption		
	level	.05	
	breastfeeding	.10	2.70*
	interaction	-.13	

[a] Adjusted for other substances and correlated potential confounds.

[b] Reported as whether the infant had exhibited sleep disturbances (yes/no).

*$p < .05$. **$p < .01$.

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